DARFUR STOVE CARBON CREDIT PROJECT

END OF SEMESTER REPORT
ER 291: DESIGN FOR SUSTAINABLE COMMUNITIES

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1.0 BACKGROUND AND PROJECT OVERVIEW

1.1 Darfur

Every day a stream of bad news flows out of Darfur and into the surrounding world; Stories of killings, rapes, mutilations, and widespread destruction. The United Nations estimates that, since the beginning of the conflict, 2.2 million people, over a third of Darfur's population, have been displaced, and that proportion could rise to half of the population within the next eighteen months.[i] In addition, many of these Internally Displaced Persons (IDPs) are subject to violence when they leave the relative safety of the camps, with the UN reporting recently on the use of rape and sexual violence as a weapon of war.[ii] Even before the escalation of the conflict in Darfur, the region was economically marginalized, and current reports confirm that the violence and displacement has further depressed human development. Malnutrition is estimated at 40%, 60% of people have no access to clean water, and child mortality rate is 3-6 times the Sub-Saharan average.[iii]

The conflict in Darfur had been simmering for some time but reached the attention of the international community roughly four years ago when the government and paramilitary *janjaweed* soldiers began to brutally suppress an uprising led by Sudanese Liberation Army/Movement (SLA/SLM) and the Justice and Equality Movement (JEM), forcing mass evacuations into camps in Sudan and neighboring Chad.[iv] The history of the struggle, a complicated historical, ethnic, and environmental mosaic, will not be addressed here.[v] It does appear clear, however, that the military and *janjaweed* have been targeting civilian populations from ethnic groups believed to be supportive of the rebels with disastrous results: in addition to the 2.2 million displaced people, at least 250,000 have been killed.[vi] Three years after entering the IDP camps, many continue to remain there with little hope of returning home in the near future.[vii]

The vast scope, complexity, and immediacy of the Darfur situation make it extremely difficult to resolve. Through low-cost appropriate technologies, however, opportunities do exist to alleviate some of the suffering and address aspects of the violence, poor health, poverty, and environmental destruction that plague Darfur. One such technology is the Berkeley-Darfur cookstove, developed by a team of Berkeley graduate students, scientists from the Lawrence Berkeley Lab (LBNL), and the San Francisco Professionals chapter of Engineers Without Borders. By reducing the amount of fuelwood needed by over 70%, this cookstove has the potential to make a real impact in the lives of IDPs in Darfur.

1.2 Berkeley-Darfur cookstove project

The Berkeley-Darfur cookstove project began in the fall of 2004 when Lawrence Berkeley National Lab (LBNL) Senior Scientist in the Environmental Energies Technology Division, Ashok Gadgil, was approached by USAID about developing a technology to turn foodwaste into fuel pellets for use in the IDP camps in

Darfur. Dr. Gadgil quickly discovered that the amount of foodwaste in the camps would be much too small to generate the quantity of fuel needed, but he was so moved by the story of the IDPs that he resolved to find some other technological hook; some way in which technology could be used to improve the dire situation in the camps. The hook, he eventually discovered, was the cookstove the IDPs in the camps were using; one of the oldest and least efficient stoves in the world: the three-stone fire.

A ring of three very large rocks, the three-stone fire transfers only about 5% of the energy of the wood to the pot as heat, meaning that a very large quantity of wood must be burned to generate enough heat for a long enough period of time to cook food. Cooking time and fuel are significant in the Darfur IDP camps because their two main food staples, *mulah*, a type of sauce made with onions and oil, and *assida,* a sticky paste of various types of flour from UN World Food Program, both require cooking. So, although the type of stove used may not seem initially to be a very important target for development, in fact, cookstoves impact the lives of the IDPs in many ways and offer opportunities for improving the quality of life of the IDPs on a number of fronts:

- *Poverty*: Due to the extreme deforestation around the camps and the danger involved in fuelwood collection, many IDP households sell food rations for cash to use to purchase fuelwood. In South Darfur, 60% of women purchase fuelwood. Of those that do so, 40% sell food rations to obtain the necessary money. 50% of families in South Darfur are missing meals for lack of fuel. In North Darfur, the zone of denudation from fuelwood collection around the camps stretches so far that 90% of women in the camps purchase fuelwood, 80% sell food rations to purchase fuel, and 90% of families are missing meals for a lack of fuel.[viii] The stove provides an estimated average savings of $160 year per household, a significant amount of money in Sudan, where per capita income is $640/yr.[ixx] Moreover, time currently spent collecting fuelwood (over 7 hours per day) can be spent on other income-generating activities.[xi]
- *Gender-based violence*: Collecting fuelwood for cooking draws women outside the IDP camps and exposes them to rape and mutilation. Using only one-third as much wood will allow women to make these trips much less frequently, reducing the occurrence of gender-based violence.
- *Health*: This more efficient stove produces fewer particulates, and thus reduces indoor air pollution, a serious problem in households with traditional three-stone stoves.
- *Environment*: Deforestation is a serious problem around the IDP camps, with the areas nearest the camps totally denuded. By reducing the amount of fuelwood needed, the Berkeley-Darfur cookstove will slow this deforestation. Slowing the deforestation will have positive impacts not only on the local environment but on a global scale as well: by our calculations, each improved stove will save 2.1 tons of carbon dioxide equivalent emissions per year, reducing this area's impact on climate change.

Once it was understood the extent to which more efficient cookstoves could improve quality of life and alleviate poverty in the Darfur IDP camps, Dr. Gadgil and a group of other scientists began work on developing a cookstove that would work in the unique conditions of the Darfur IDP camps. Many of the breakthroughs of this development occurred in field visits to the camps where various types of stoves (including the rocket stove, mud stove, and "Tara" stove) were tested using side by side cooking demonstrations with local women. In these demonstrations, multiple 250 gram stacks of fuelwood were laid out in front of each stove, and groups of women began cooking *mulah* and *assida* on the different stoves simultaneously. It was then easy for the participants and audience (as many as 300 people, mainly women and sheikhs would attend a demonstration) to see which stoves cooked faster and used less wood.[xii]

In these demonstrations and other tests at LBNL, the "Tara stove," developed for low-income peasants in India, was clearly superior but lacked certain characteristics that would make it effective for the Darfur IDPs. Specifically, the stove did not fit the traditional round-bottom pots well, and it was not stable enough for the vigorous stirring required for the traditional meals. Upon return to Berkeley, a team of researchers began to work on modifying the stove for Darfurian conditions. Through the Spring 2006 University of California, Berkeley Sustainable Communities class, a group of graduate students took on the re-design project, and produced a prototype that was more stable, was designed to hold the round-bottom pots, and used 70% less fuelwood than the traditional three-stone fire.[xiii] The students then joined forces with the San Francisco Professionals chapter of Engineers Without Borders in order to harness their expertise in metalwork and manufacturing to produce a stove design that could be mass-produced at a low cost.

This stove has since been tested in Darfur in side-by-side comparisons as well as by fifty IDP households that purchased the stove and provided feedback on its use. This technical roll-out was overseen by a volunteer from Engineers Without Borders, with local coordination and support from an international non-governmental organization, CHF International, which has extensive operations inside the Darfur IDP camps. Due to positive feedback from the technical roll-out, Engineers Without Borders and CHF decided to proceed with a slightly larger social roll-out of 5,000 stoves, which is underway currently but, due to lack of funding, has been reduced to 3,000 stoves. In order to contribute to local economic development, most materials for the current trials are being purchased inside Sudan, and manufacturing is located at a workshop in Khartoum, providing local opportunities for employment. [xiv]

1.3 Project Overview

Given that the technological issues with the stove appeared to be solved, our project for the semester was to find $9 million in funding through the carbon market to enable CHF International to distribute 300,000 Berkeley-Darfur stoves in the Darfur IDP camps.[xv] To do so, we first had to research the various carbon markets and learn the process of generating and selling carbon credits, then apply that knowledge to discover how the Berkeley-Darfur cookstove fit into that framework. More specifically, we were interested in finding a way to calculate, in a scientifically and politically credible way, how many metric tons of carbon dioxide equivalent (CO2e) emissions would be reduced per stove and, once calculated, how we could prove that those emissions would actually occur. Once that methodology was in place, our next step would be to find willing buyers for those credits and work with CHF International to ensure that a detailed and comprehensive process was in place for stove distribution as well as carbon credit monitoring and verification. Our initial target buyer was to be Pacific Gas and Electric, which had recently launched a carbon neutral initiative, but in our initial research we also examined other avenues of carbon funding and identified other potentially interested buyers.

In addition, we were set the task of learning about the nascent California carbon market and attempting to raise awareness of projects like ours in order to persuade policymakers to design that market (as well as other carbon markets and buyers within the U.S.) to be more accessible to cookstove and other development projects.

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2. CARBON MARKET OVERVIEW

Carbon markets are formed when some sort of regulatory ceiling or cap on emissions is put in place, and trading of emissions under the cap is allowed. Setting a fixed number of tons of carbon (or, in most cases, carbon dioxide) that can be emitted and allowing those tons to be traded gives a value to each of those tons as they are bought and sold to enable market members to meet their regulatory targets. Carbon trading happens when market members that can cheaply and easily reduce their emissions below their limit do so and then sell any extra allowable carbon dioxide emissions (the difference between their actual and allowed emissions) to other market members for whom it is too difficult or expensive to meet their own targets. In this way, the aggregate number of tons of carbon dioxide from all market members stays below the emissions cap, but the flexibility that results from the market means that not every member must make significant reductions; Those that can will have incentive to reduce as much as possible to earn more emissions to sell.

The Kyoto Protocol greenhouse gas (GHG) emissions cap that went into effect in 2005 enabled the creation of markets in which the right to emit tons of carbon dioxide equivalent (CO2e) can be bought and sold. Still in its incipient stages, the global carbon market is in flux, and prices and regulations vary widely both temporally and between the various markets at a single point in time. In order to narrow down opportunities for the Berkeley-Darfur to sell carbon credits, we utilized a framework that divides the global carbon market into three distinct types, each with its own potential costs and benefits for our project. Below we give a general description of each of these types of markets, examples and some of the advantages and disadvantages of each as they pertain to the Berkeley-Darfur cookstove project; for a more detailed description and assessment of carbon markets, please see the paper by Hepburn, 2007.[xvi]

2.1Mandatory

The vast majority of carbon traded throughout the world, both by volume and by value, is traded through mandatory markets created by the Kyoto Protocol as flexible mechanisms to help developed countries meet their Kyoto emissions targets more cheaply and efficiently. The Kyoto Protocol divides its member nations into two groups: Annex I, the industrialized and developed countries, and non-Annex I countries, those countries that are less developed and had not contributed significantly to the global greenhouse gas concentrations as of 1990. Annex I countries who are signatories to the Kyoto Protocol must meet their agreed-upon and binding emissions targets, either by reducing emissions in their own countries, paying for emission-reduction projects in non-Annex I countries, or through some sort of carbon credit trading mechanism.

The largest carbon market in the world, the European Climate Exchange (ECX), is one such mechanism. Open for trading as of January, 2005, the ECX, as the name implies, is the trading platform for the European Union Greenhouse Gas Emission Trading Scheme (EU ETS), through which European nations that have signed on to the Kyoto Protocol can buy and sell the right to emit carbon. Under the EU ETS, each participating country developed a National Allocation Plan (NAP) which sets a greenhouse gas emissions ceiling for their utilities and some of the major polluting industries (such as oil refineries). Based on this plan, companies within that country are given a certain number of European Allowances (EUAs), each representing a ton of CO2 that can then be bought and sold on the ECX.

In addition to trading these allowances amongst themselves, ECX members can also generate additional tradable carbon credits through the Clean Development Mechanism (CDM). Also authorized under the Kyoto Protocol, the CDM was originally designed to further sustainable development by allowing Annex I countries to undertake carbon emission reduction projects in non-Annex I countries and to count those emission reductions towards their own emissions targets. The emission reductions credits generated through the CDM are called Certified Emissions Reductions (CERs). These CERs do not have to be traded on the ECX; any Annex I country can sponsor a CDM project and apply the CERs towards their Kyoto goals or an industry involved in the ECX can sponsor a project and trade those CERs. Although CERs are technically equivalent to EUAs, they are usually traded at a lower value due to the higher level of risk involved.

2.2 Contractual

In addition to these mandatory markets for Kyoto Protocol member nations, some outside efforts have sprung up to involve entities that are not bound by the Kyoto Protocol. One of these types of efforts, the largest of which is the Chicago Climate Exchange (CCX), can best be characterized as contractual because it is neither fully mandatory, or, once entered into, fully voluntary. In these markets, members, usually individual companies or governmental agencies, join voluntarily but in doing so agree to binding emissions targets. The details regarding the tools they can use to meet these targets varies between markets. In the Chicago Climate Exchange, members can trade Exchange Allowances, which are based on their own emissions, or Exchange Offsets, which are basically carbon credits generated by mitigation projects that are not part of any market member. For example, a dairy farmer in Washington who has made no binding agreement to be part of the CCX and reduce his own emissions can capture the methane from his cattle and offer that emission reduction on the market as an Exchange Offset that a market member may buy to help meet their own emissions targets. Exchange Offsets can be sold directly on the market or to approved aggregators who bundle multiple small projects and offer the whole portfolio on the market.

As one of its offset categories, the Chicago Climate Exchange accepts CERs from any eligible CDM projects, but currently the only offset projects outside of the United States on the CCX are in Canada, Mexico, Costa Rica, and China. In addition to CDM approved projects, the types of offset projects currently allowed on the CCX are limited to methane destruction, agricultural practices, forestry practices, emission mitigation in Brazil, and renewable energy development.

Carbon prices on the CCX are generally lower than on the ECX, but the process is more streamlined and transaction costs are lower than those for CDM projects. Besides the CCX, other contractual markets that have been authorized include one for the state of California and another for the nine states of New England.

2.3 Voluntary

In addition to the mandatory and contractual carbon markets, a kind of diffuse, purely voluntary market has arisen as well. This market has no authorized trading platform, no agreed-upon emissions ceilings, and little in the way of certification or verification. The buyers in this market may be any individuals or corporations that desire to offset their own carbon emissions by buying credits from other entities that either have reduced their own emissions or are generating renewable, carbon-neutral energy. For example, that same dairy farmer in Washington may sell his methane emissions reductions to Joe's Bakery, a company that cares about global warming but does not feel it can afford the capital investment to reduce its own emissions. Because a ton of carbon dioxide emissions avoided anywhere are considered more or less equivalent, it is as if Joe's has reduced its own emissions by funding the dairy farmer to reduce his. Of course, this is only true if that dairy farmer would not have been willing or able to reduce his methane emissions without Joe's financial support; otherwise, that emission reduction is essentially being counted twice. This idea that emissions reductions must go beyond what would have happened in a business-as-usual or baseline scenario is called "additionality," and both the mandatory and contractual markets demand it from their offset projects. The voluntary market, however, has no real safeguards to assure that its projects are additional or even that they have actually occurred. In the absence of regulations for the voluntary market, buyers are placing a great deal of trust in the sellers who say that they are generating real carbon emission reductions.

Corporations and individuals may buy carbon credits for a variety of reasons: as a hedge against future regulations, for altruistic purposes, for positive publicity and/or for financial gain. In addition to these ultimate buyers, middlemen aggregators have also appeared in this market to bundle multiple offset projects together and sell the carbon credits from the portfolio to individuals or companies. Some of these aggregators, like Terrapass and Climate Care, may offer buyers a bit more certainty in their purchases by certifying and verifying the carbon reductions of any projects that they include in their portfolio.

The voluntary market is the most flexible of the three types, and projects may get by with very few transaction costs. In addition, projects that would have difficulty meeting the burden of proof demanded by the mandatory market are freer to operate in this voluntary market that is virtually lacking any sort of regulation and may be rewarded for other socially beneficial aspects of the project that would be outside the bounds of a mandatory market that focuses exclusively on carbon. However, prices on the voluntary market may be lower, and some transaction costs that may be avoided in the voluntary market, such as monitoring and data verification, may be balanced out by increased costs of searching out willing buyers and marketing the project.

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3. USING CARBON CREDITS TO FUND COOKSTOVE PROJECTS

3.1 Carbon Credit Generation

Although biomass is generally thought of as a carbon neutral fuel, biomass that is harvested and combusted at a rate that exceeds its rate of regrowth is actually a source of atmospheric carbon dioxide. In this instance carbon capture by new growth is not sufficient to offset carbon release through combustion. [xvii] In carbon market literature and policy discussions, biomass that is harvested at unsustainable rates (*i.e.* harvest rate exceeds rate of growth and establishment of new biomass) is called "non-renewable biomass," or "NRB." Because of increased population densities in the IDP camps in Darfur and the lack of reforestation, the fuelwood used in the IDP camps is harvested unsustainably (as can be seen by the widening zone of denudation around the camps) and therefore qualifies as NRB. As NRB, the fuelwood burned in the IDP camps is considered to have positive atmospheric carbon dioxide emissions; thus, by reducing the amount of NRB fuelwood that is burned, we reduce atmospheric carbon dioxide emissions, and for each metric ton of those reductions, we theoretically generate one carbon credit that can be sold on the market.

In addition, stoves that burn inefficiently create a number of products of incomplete combustion (PICs), many of which have global warming potential and some of which fall under the Kyoto Protocol as emissions that can be traded on the mandatory market, including methane and nitrous oxide. In fact, some of these gases actually have a much higher global warming potential than carbon dioxide and could thus potentially become a large source of carbon revenue even if the actual quantity emitted is fairly small. Because it is more efficient than the 3-stone fire, the Berkeley-Darfur cookstove should reduce at least some of these PICs significantly. As of now, however, tests have not been done to quantify the PIC reduction using the Berkeley-Darfur cookstove, and our team was wary to include PIC calculations in our carbon accounting methodology because they vary greatly depending on cooking technique. Due to this large variation in emissions reductions of PICs, a proper protocol to monitor them would need a larger, more complex sampling procedure to get values with statistical validity, all of which would increase project overhead.

3.2 Opportunities in the Carbon Market

While the European Carbon Exchange remains strictly a market for the European Union signatories of the Kyoto Protocol to sell carbon credits for reductions made within each country, there are still opportunities for development and specifically, cookstove projects on the mandatory market. The Clean Development Mechanism (CDM) allows Annex I countries to fund development projects in non-Annex I countries and have that credit count towards their emissions reduction goals. The CDM was originally created to further sustainable development in non-Annex I countries, while still contributing to the underlying goal of carbon emissions reductions.

As outlined in section 2.2, the contractual carbon markets like the Chicago Climate Exchange (CCX) accept the Certified Emissions Reductions (CERs) generated through CDM projects. Additionally, the voluntary carbon markets have no general restrictions against development based carbon emissions reduction projects, and several buyers on the voluntary market have already shown interest in the carbon credits generated through the Berkeley-Darfur cookstove.

3.3 Challenges in the Carbon Market for Cookstove Projects

While projects like the Berkeley-Darfur cookstove have a number of opportunities for receiving funding through the various types of carbon markets, small-scale development projects also face a number of challenges including an aversion to projects involving non-renewable biomass, developing affordable yet accurate monitoring and verification procedures, and the lack of a standard methodology to estimate the credits generated through the project.

3.3.1 Non-Renewable Biomass History in the CDM

Initially, small-scale CDM projects within the Kyoto Protocol were allowed to generate carbon credits through reducing harvesting of non-renewable biomass (NRB), either through energy-efficiency improvements of systems using unsustainable biomass or substitution of technologies utilizing renewable energy instead of biomass. Due to concerns regarding leakage and incentives for deforestation, this allowance was removed from the CDM protocol and, years later, has yet to be replaced, although parties have requested that the Executive Board prioritize finding an acceptable replacement. The voluntary markets do not have a formal bias against NRB projects, but in the absence of an agreed-upon methodology from the UNFCCC, a great deal of confusion still exists about whether to accept these projects and, if so, how to do correctly account for, monitor, and verify carbon emissions reductions.

3.3.2 Monitoring and Verification Protocols

One of the biggest challenges for cookstove projects to be considered for carbon credit funding is how to monitor and verify that the emissions reductions are actually occurring in the field. Unlike most of the CDM projects centered around cleaning up industry in China, Brazil, and India, cookstove projects operate at a much smaller and more dispersed level. The sheer difference in scale of these projects compared to the typically approved projects creates the monitoring and verification challenges. While the characteristic industry projects involve monitoring only the single source of carbon emissions, projects like the Berkeley-Darfur cookstove must find a way to monitor and verify reductions accurately to assure final buyers, but also cheaply to keep overhead costs down and maintain financial viability within the project.

Our project recognizes this challenge and is working with both Engineers Without Borders and CHF International to develop monitoring and verification protocols, to be conducted simultaneously with the stove rollout, that are accurate enough to withstand market scrutiny, but also cheap enough to keep the project financially feasible. Depending on the funding source, and resources through CHF International, monitoring will be done either by utilizing the stove-testers previously trained by CHF International to conduct household-level surveys of fuelwood usage, before and after project implementation, or by monitoring fuelwood usage on a camp-level basis, before and after the cookstove dissemination.

3.3.3 Methodology

In order to trade carbon credits under any of these market options, buyers and sellers must agree on how to correctly account for the carbon emissions reductions and how to verify that they have occurred. The most challenging barrier to using carbon credits to fund development projects is that, currently, there is no universally accepted or standard methodology for quantifying carbon emissions reductions from projects that reduce use of non-renewable biomass.

3.4 Our Methodology

Deciding on a methodology to appropriately and correctly estimate the emissions reductions associated with the Berkeley-Darfur cookstove became one of this project's most difficult tasks. We initially began by developing our own methodology based on fuelwood usage and stove efficiencies (see Figure 1), but later, recognizing the scrutiny biomass-based development projects undergo, we realized the need for the methodology used to carry more clout.

Original Emissions Estimate Methodology

The basic methodology is to calculate the amount of fuelwood saved per year using the Berkeley Stove instead of the traditional 3-stone fire. Assuming no leakage, every kilogram of fuelwood saved corresponds to an associated amount of reduction in carbon dioxide (CO_2) emission. Therefore, once calculated, the amount of fuelwood reduction can be converted to reduction in CO_2-equivalent.

3-Stone Fire Fuelwood Use

The amount of fuelwood used per year using a 3-stone fire is estimated in Table 1. Firewood use data are taken from Galitsky et al, 2006 (*see endnote VIII for full citation)*:

Table 1: Methodology for calculating the total fuelwood used per year by Darfur IDPs. Please note the units are in brackets [*units*]

(Total Darfur IDP Families)	*	(Daily Fuelwood Use per Family)	*	(Fraction Family Using 3-Stone Fire)	*	(Days per Year)	=	(Total Darfur IDP Fuelwood Use per Year 3-Stone Fire)
285,714		5.00		0.9		365		469,285,714
[*family*]		[*kg*/(*day***family*)]				[*day*/*year*]		[*kg*/*year*]

Berkeley Stove Use

The fraction fuelwood used by the Berkeley Stove compared to the traditional 3-stone fires used is estimated in Table 2. Data in Table 2 are taken from Kirubi et al, 2006 (*see endnote XIII for full citation)*:

Table 2: Methodology for estimating the fraction of fuelwood used by the Berkeley Stove compared to the traditional 3-stone fire

(Tara Stove/3-Stone Fire)[1]	*	(Berkeley Stove/Tara Stove)[2]	=	(Berkeley Stove/3-Stone Fire)
0.57		0.55		0.31

The amount of fuelwood used per year using a Berkeley stove is estimated in Table 3:

Table 3: Methodology for estimating the amount of fuelwood used per year by Darfur IDPs using the Berkeley Stove

(Berkeley Stove/3-Stone Fire)	*	(Total Darfur IDP Fuelwood Use per Year 3-Stone Fire)	=	(Total Darfur IDP Fuelwood Use per Year Berkeley Stove)
0.31		469,285,714 [*kg/year*]		146,805,868 [*kg/year*]

Subtracting the estimated total amount of fuelwood used per year by Darfur IDPs using the Berkeley Stove from the estimated total amount of fuelwood used per year by Darfur IDPs using the 3-stone fire yields the amount of fuelwood saved by using the Berkeley Stove instead of the 3-tone fire, Table 4.

Table 4: Methodology for estimating the amount of fuelwood saved by using the Berkeley Stove instead of the 3-stone fire

(Total Darfur IDP Fuelwood Use per Year 3-Stone Fire)	-	(Total Darfur IDP Fuelwood Use per Year Berkeley Stove)	=	(Amount of Fuelwood Saved per Year Using Berkeley Stove)
469,285,714 [*kg/year*]		146,805,868 [*kg/year*]		322,479,846 [*kg/year*]

Emissions are estimated based on Kirk, 1994[xviii]

Emission Gas	*Percent Emitted	Amount Saved per Year Using Berkeley Stove
CO_2	88%	283,782,265
CO	8.7%	28,055,747
CH_4	1.6%	5,159,678

*Assuming a stove efficiency of 20%

Figure 1: Initially Developed Methodology

This led us to Robert van Buskirk, a researcher at LBNL, who had completed a similar project and had been able to sell the generated carbon credits on the voluntary market to fund a cookstove project in Eritrea[xix]. Recognizing the success of his project and his confidence in the developed methodology led to adapting his carbon accounting for the Berkeley-Darfur cookstove. However, this methodology turned out to be far too complicated for this project, especially to explain to potential carbon credit buyers. While ultimately this methodology may have been more accurate, by accounting for potential leakage and the residence time of unharvested biomass in the environment, it was unlikely that monitoring and verification productions through this methodology would remain feasible and affordable.

Eventually, we discovered a methodology similar to the one we initially developed, but carried the authority of the World Bank and the Household Energy Network (see Figure 2). We decided to use this methodology because it is backed by the influence of the World Bank and allows for straightforward monitoring and verification procedures.

World Bank and Household Energy Network Methodology [xx]

Technology/ Measure

1. This category comprises small appliances involving the switch from non-renewable biomass such as fuelwood or charcoal to renewable energy technologies. These technologies include biogas stoves, use of solar cookers and measures that involve the switch to renewable biomass.

Boundary

2. The project boundary is the physical, geographical area of the use of non-renewable biomass or a mixture of non-renewable biomass and modern fuels.

Baseline

3. It is assumed that in the absence of the project activity, the baseline scenario would be the mix of non-renewable biomass and modern (fossil) fuels use expected to be used in the baseline, by the local consumers, for meeting similar thermal energy needs. Project proponents must demonstrate that the biomass use claimed to be non-renewable is indeed non-renewable, following the EB 23 Annex 18 definition of renewable biomass. This can be done by factoring out the renewable biomass in the rural and urban biomass use assessing the proportion of non-renewable biomass from the household surveys.

Data on fuelwood usage comes from Galitsky et al, 2006 (*see endnote VIII)*. Data on stove efficiency is estimated from Kirubi et al, 2006 (*see endnote XIII)*. All other numbers and calculations come directly from the World Bank Methodology as cited in endnote XX.

<u>Baseline Emissions:</u>

$BE_y = B_y * NCV_{biomass} * EF_{baseline,\ CO2} * 10^{-3}$

Where:

BE_y baseline emission per year

B_y Quantity of non-renewable biomass used in tonnes, calculated as the product of the number of appliances/HH and the estimate of average annual consumption of NRB/appliance/household^{-1} (tonnes/year).

1 appliance/HH $*$ .005t biomass/HH/day $*$ 365 days/yr = 1.825 t/yr biomass

$NCV_{biomass}$ Net calorific value of NRB (IPCC default for wood fuel, 15 MJ/Kg)

$EF_{baseline,\ CO2}$ Weighted average of emissions from modern fuels and non-renewable biomass

$= X' * EF_{co2,\ fossil\ fuels} + PNR * (1 - X') * EF_{NRB,\ CO2}$

$X' = X + R * X * n$

X = Share of modern fuels (kerosene and LPG) in the baseline given current trends.
Estimate: 1%

R = Average rate of adoption of modern fossil fuels in percent under baseline.
Estimate: 1%
n = lifetime of each stove (5 years)

$X' = 0.01 + 0.01 * 0.01 * 5$
$X' = 0.0105$

$EF_{CO2,\ fossil\ fuels} = (EF_{kerosene} + EF_{LPG}) / 2$
Since no LPG used in camps,
$= EF_{kerosene}$
=71.5 tCO2/TJ

PNR Percent of biomass that is non-renewable
Estimate: 100%

1-X' Share of biomass fuels in baseline (both sustainable and non)
1-X' = .9895

$EF_{NRB,\ CO2}$ =109.6 tCO2/TJ (default for biomass IPCC 1996)

$$EF_{baseline,\ CO2} = X' * EF_{co2,\ fossil\ fuels} + PNR * (1 - X') * EF_{NRB,\ CO2}$$
$$= 0.0105 * 71.5\ tCO2/TJ + 1 * .9895 * 109.6\ tCO2/TJ$$
$$= 109.2\ tCO2/TJ$$

Baseline Emissions (BE): $= 1.825$t/yr biomass $* 15$MJ/kg $* 109.2$ tCO2/TJ $* 10^{-3}$
= 3.0 tCO2/yr

<u>Project Emissions</u>

$$PE = P_y * NCV_{biomass} * EF_{project} * 10^{-3}$$

Where:
P_y = Non renewable biomass usage under project

Assume the Berkeley-Darfur stove uses 0.3 times as much wood as the 3 stone fire, we estimate:
1 stove/HH $*$ (0.3 $*$ 0.005 t biomass/HH/day $*$ 365 days/yr)
= 0.548t biomass/HH/yr
$NCV_{biomass}$ = Same as above. 15MJ/kg
$EF_{project}$ Assumed to be same as above because fuel share is not changing. This number is conservative because more efficient stoves generally have lower emissions factors because they reduce products of incomplete combustion (PICs), many of which have high CO2e values.
= 109.2 tCO2/TJ

Project Emissions (PE) = 0.548t biomass/yr $*$ 15MJ/kg $*$ 109.2 tCO2/TJ $* 10^{-3}$
= 0.9 tCO2/yr

Emissions Reductions (Per Stove)

ER = BE – PE
ER = 3.0 tCO_2/yr – 0.9 tCO_2/yr
Emission Reductions (ER) = 2.1 tCO_2/yr

Total Emissions Reductions

ER ∗ number of households adopting =
2.1 tCO_2/yr/HH ∗ 300,000HH = 630,000 tCO_2/year

ER ∗ number of HH adopting ∗ lifetime of stove (5 years) =
2.1 tCO_2/yr HH^{-1} ∗ 300,000HH ∗ 5 yrs = 3.1 M tCO_2 over lifetime of project

Figure 2: World Bank and Household Energy Network Methodology

One of the major strengths of using this methodology lies in the influence of the World Bank, but also that it allows each stove to be considered as an individual project, allowing leakage concerns to be neglected. However, concerns of accuracy, considering the optimal scale of the project, leave questions regarding leakage unanswered. Another weakness of this methodology is that it only accounts for the amount of carbon dioxide reduced, and does not consider the global warming potential of many of the products of incomplete combustion (PICs) released during the cooking process. While focusing only on CO2, and ignoring the PICs, this methodology does not calculate the most reductions possible, but it does offer the most robust and conservative emissions reductions estimate.

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4. CURRENT STANDING AND WAY FORWARD

4.1 Stove Project Field Status Report

The following is a summary (Note: some excerpts are verbatim) of the major issues from the latest field status report submitted by Michael Helms (Engineers Without Borders) from Sudan on Wednesday, April 11, 2007. It is here submitted as the most current status of the Berkeley Darfur Stove Project in Sudan. For more detail, please see the text of the report in the submitted binder: *Fuel-Efficient Stove - Project Status Report Prepared at the CHF International guesthouse in Khartoum, Sudan Friday 07 April 2007 to Wednesday April 11*. Please see Ashhok Gadgil for updates and status reports post-April 11, 2007.

4.1.1 Budget

The original budget from USAID's OFDA to CHF for this project is reported to be approximately $95,000. Of this, $30,000 was to be spent on R&D, and $65,000 on stove manufacture (5000 stoves at $13 each). Just the 5000 grates by themselves cost $57,500 - so the budget was severely broken at the very moment the cast iron grate purchase was made in Khartoum. Including with this various other expenditures, the remaining funds in the stove budget for the first 5000 stoves total approximately $23,800 There are approximately $21,000 in funds at CHF-HQ (from Global Giving and other donors) to pay for other costs. This account is also intended to pay for purchase and shipment of project tools (most notably 5 spot welders, spare parts, 5 sheet metal brakes). It is not known if the existing funds will cover all of the costs mentioned.

4.1.2 Materials
It is not know if all of the needed stove materials can be procured in Nyala, Sudan.

4.1.3 Stove Assessment
An assessment was performed on the first 50 stoves that were sold to IDPs for the subsidized price of $5 each. It was found that 30-50% of the stoves were not being regularly used by the IDPs. The metal stakes that were supplied with the stoves had vanished from all of the evaluated stoves for, as of then, unexplained reasons. The assessment suggests that specific design modifications are necessary to ensure stability and that stoves are used by the IDPs.

4.2 Getting Funding
The following is a summary of our current and suggested funding efforts.

4.2.1 Solicitation Document and 5 Minute Pitch
A solicitation document was developed (Please see Appendix). The solicitation document includes details of the Berkeley Darfur Stoves Project and requests a meeting to discuss the targeted company's investment in carbon credits generated from the Berkeley Darfur Stoves. It is recommended that the solicitation document be printed on University of California, Berkeley letterhead. Please see section 4.2.2 for an initial list of organizations to be targeted.

A 5 minute presentation was also created and is currently under revision. The presentation is intended as a presentation version of the solicitation document. Please see Ashok Gadgil for the latest version of the presentation.

4.2.2 Initial Targets
The following are an initial list of target organizations. These organizations either have previously shown interest in the Berkeley Darfur Stoves project or have been identified as having a higher probability of success.

1. Pacific Gas and Electric Company (PG&E)
2. Climate Care
3. Chicago Climate Exchange (CCX)
4. The Dow Chemical Company

PG&E has shown interest. Art Rosenfeld and Wendy Pulling are the current contacts. Please see Ashok Gadgil for the latest on the current relationship with PG&E and contact information.

Climate Care has previously funded NRB stove projects. The Climate Care organizational website is: http://www.climatecare.org/

The CCX is currently the largest US-based carbon market. At this point the CCX does not accept NRB-based reductions. However, it is anticipated that as the market matures NRB-based reductions will be considered. The CCX organizational website is: http://www.chicagoclimatex.com/

The Dow Chemical Company has shown interest and wishes to be kept abreast of the status of the Berkeley Darfur Stoves Project. The contact for Dow Chemical is Cuthbert E. Roberts:

Cuthbert E. Roberts
Energy Business Development Director
The Dow Chemical Company
ceroberts@dow.com
Tel: 713-978-2367

4.2.3 World Bank

The CHF International is seeking funding for the Berkeley Darfur Stove Project through the World Bank. Dennis Dragovic is leading the CHF International efforts. To date, the major concerns shown by the World Bank are the same concerns voiced by the Executive Board of the CDM, i.e. that a universally accepted methodology to account for carbon emissions reductions associated with NRB projects does not exist. The World Bank has shown a genuine interest. However, they have pushed back any decisions or meetings with regard to the Berkeley Darfur Stove Project to the end of May 2007.

4.4 Policy Outreach to Developing Markets/Industries

Per Assembly Bill 32 (AB32), the California carbon market is its incipient stages. As such, it is here recommended that California legislators and policymakers be lobbies to considered NRB development projects as an option where carbon trading is considered. The solicitation document and 5 minute presentation can be re-worked to target legislators and policymakers.

It is also hoped that through soliciting identified targets (e.g. PG&E, CCX, etc) that the benefits of NRB based development projects will be brought to light and locally, nationally, and globally.

4.5 Miscellaneous Support

A binder has been developed with additional supporting documentation.

Dr. Kirk Smith (University of California, Berkeley School of Public Health) has vast experience in stove-related projects and is currently addressing similar issues. Dr. Smith has expressed a genuine interest in supporting Berkeley Darfur Stove Project efforts.

Dr. Robert Van Buskirk (Lawrence Berkeley National Laboratory) has successfully received funding for a NRB stove project in Eritrea. Dr. Van Buskirk proved a valuable asset during the semester and is interested in further supporting Berkeley Darfur Stove Project efforts.

5. APPENDIX-SOLICITATION DOCUMENT

Dear Sir/Madam:

Federal, state, and local governments are rapidly making commitments to reduce greenhouse gas emissions (GHGs); California, for example, has announced an objective to reduce carbon emissions by 80% of 1990 levels by 2050, the United Kingdom a 60% reduction of 2000 levels by 2050, and China a 20% reduction in energy intensity of GDP by 2010.

Typical emissions reductions traded on carbon markets are associated with renewable energy and reforestation. However, while the benefits of investing in renewable energy and reforestation projects as carbon offsets are substantial, the opportunity does exist to invest in projects that go beyond climate benefits. Many multifaceted projects in developing countries include elements of public health, poverty reduction, and environmental sustainability, all the while substantially reducing carbon emissions.

The new and developing American and international carbon trading markets offer significant opportunities to reduce a company's carbon emissions while investing in these multifaceted development projects that offer additional social benefits. Taking action to reduce GHG emissions now, before emissions targets in the United States become binding, will generate carbon offset credits that will be valuable in the future. Doing so while simultaneously contributing to public health, poverty reduction, and environmental sustainability makes good business sense.

With research conducted at the University of California at Berkeley (UCB), Lawrence Berkeley National Laboratories (LBNL), and with implementation support by CHF International, we would like to propose just such a project for your investment portfolio: a viable development project that has carbon emissions-reduction, local environmental benefits, and humanitarian dimensions; a true win-win-win.

UCB/LBNL has developed a fuelwood efficient stove, specific to the unique cooking and social-cultural conditions of the refugees in Darfur.. Fabricated in Darfur and retailing for US$30 a piece, the stove saves 70% of fuelwood, resulting in emissions reductions of 2.1 tons of CO_2e per stove per year. In addition to reducing environmental degradation (a major cause of the current conflict), additional benefits include creating local employment, decreased indoor air pollution, and significant financial savings from reduced fuelwood consumption. As refugees often trade food rations donated by the UN-World Food Program for fuelwood, large-scale and rapid deployment of stoves can be a cost-effective strategy of addressing chronic malnutrition in the camps. Additionally, less fuelwood consumption would result in less exposure to violence, rape, and mutilation for women collecting fuelwood outside of camp boundaries. (Note: It is far more dangerous for a man to leave the camp boundaries to collect fuelwood.)

We estimate that deploying 300,000 stoves in the Darfur refugee camps would result in 600,000 carbon credits (metric tonnes of CO2e) per year. These carbon credits, valued at \$6 per ton of CO2, represent a potential funding source of \$3.6 million per year.

We would very much like to discuss with you the possibility of investing in these fuel efficient stoves as a method of reducing your company's carbon emissions while simultaneously providing much-needed humanitarian assistance to the war-torn Darfur region.

Please let us know if you have any questions, concerns, or if you would like to schedule a meeting.

Looking forward to working with you,

Berkeley Darfur Stove Group
darfurstoves@lists.berkeley.edu

Postscript:
CHF International is a not-for-profit development organization working in over thirty countries. Over the past two years CHF has partnered with the Lawrence Berkeley National Laboratory in California, US, and the University of California at Berkeley, to develop the aforementioned fuel efficient stoves for the people of Darfur, Sudan. The project is now in its 2nd phase with a roll out of 3,000 stoves having started in May 2007.

The unique circumstances of Darfur, including high density living, insecurity beyond camp borders, and a large presence of international organizations, all support this project. High density living minimizes distribution costs and increases accessibility for training and socialization of the product; Insecurity beyond camp boundaries eliminates the concern of leakage and the large number of international organizations present minimizes overhead operational costs, verification costs, while providing the necessary on-the ground operational and logistical support for the dissemination of the 300,000 stoves.

For more information please visit:
Lawrence Berkeley National Laboratory Darfur Cook Stoves page at: http://darfurstoves.lbl.gov/
CHF efforts in Sudan page at: http://www.chfhq.org/content/general/detail/2927/

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LBNL
Kirk Smith
Barbara Haya
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Charles Kirubi
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[i] United Nations Security Council Press Release. April 4, 2007. Accessed April 16, 2007. Available from: http://www.un.org/News/Press/docs//2007/sc8993.doc.htm.

[ii] United Nations Press Release. High Commissioner for Human Rights Calls for Probes of Incidents of Sexual Violence, Disappearances in Sudan's Jebel Marra and South Darfur. April 6, 2007. Accessed April 16, 2007. Available from: http://www.unhchr.ch/huricane/huricane.nsf/0/46AA541D34B02A41C12572B50033EDF9?opendocument.

[iii] United Nations Human Development Report, Chapter 5. Violent conflict-- bringing the real threat into focus. 2005. Accessed April 16, 2007. Available at: http://hdr.undp.org/reports/global/2005/pdf/HDR05_chapter_5.pdf.

[iv] Coalition to Save Darfur. March 31, 2007. Background. Accessed May 7, 2007. Available at: http://www.savedarfur.org/section/about/.

[v] An excellent account of the history of Sudan and the Darfur conflict can be found in the book *Darfur: the ambiguous genocide* by Gerard Prunier. Cornell University Press, 2005.

[vi] Coalition to Save Darfur. March 31, 2007. Background. Accessed May 7, 2007. Available at: http://www.savedarfur.org/section/about/.

[vii] United Nations Security Council Press Release. April 4, 2007. Accessed May 10, 2007. Available from: http://www.un.org/News/Press/docs//2007/sc8993.doc.htm.

[viii] Galitsky, C., Gadgil, A., Jacobs, M., Lee, Y., 2006, "Fuel efficient stoves for Darfur IDP camps: Report of field trip to North and South Darfur, Nov. 16-Dec. 17, 2005." Lawrence Berkeley National Laboratory (LBNL)- 59540. University of California, Berkeley.

[ix] Galitsky et al. 2006.

[x] World Development Indicators database. World Bank. July 1,2006.. Gross National Income per capita, 2005.

[xi] Galitsky, et al. 2006.

[xii] Galitsky, et al. 2006

[xiii] Kirubi, C., Woo, J., Amrose, A., and T. Kisch. 2006. Saving lives and the environment with improved cookstoves in Darfur, Sudan. End of Semester Report ER291: Design for Sustainable Communities. Available at: http://eetd.lbl.gov/staff/gadgil/teaching.html

[xiv] Further information and updates on the cookstove roll-out are available from www.darfurstoves.lbl.gov

[xv] Please see the financial worksheets attached, developed by Denis Dragovich of CHF, International.

[xvi] Hepburn, C. 2007. Carbon trading: a review of the Kyoto mechanisms. Draft: March 19, 2007 for Annual Energy Reviews. Please see attached but do not disseminate.

[xvii] Gadgil, Ashok, David M. Greene, and Art Rosenfeld. 1998. Energy Efficient Drinking Water Disinfection for Greenhouse Gas Mitigation. ACEEE.

[xviii] Smith, K. 1994. Health, energy, and greenhouse-gas impacts of biomass combustion in household stoves. Energy for Sustainable Development, 1(4): 23-29.

[xix] Van Buskirk, Robert. 2005. Verification Document for Eritrea Dissemination of Improved Stoves Program (EDISP) for Vintage 2003 Credits. Appendix A. VER Estimation Methodology. Available at: http://www.punchdown.org/rvb/mogogo/EDISPVerifyDoc200401final.html#AppendixA

[xx] Household Energy Network. 2006. Small Scale CDM Projects and Non-Renewable Biomass. Available at: http://www.hedon.info/docs/WBNonRenewableBiomassNoteSept1373.pdf